

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



10/53/907



(43) International Publication Date  
26 August 2004 (26.08.2004)

PCT

(10) International Publication Number  
WO 2004/073067 A1

(51) International Patent Classification<sup>7</sup>: H01L 27/14,  
27/146, H04N 5/32

(21) International Application Number:  
PCT/JP2004/001429

(22) International Filing Date: 10 February 2004 (10.02.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
2003-036834 14 February 2003 (14.02.2003) JP

(71) Applicant (for all designated States except US): CANON  
KABUSHIKI KAISHA [JP/JP]; 3-30-2, Shimomaruko,  
Ohta-ku, Tokyo, 1468501 (JP).

(72) Inventors; and

(75) Inventors/Applicants (for US only): NOMURA, Kei-  
ichi [JP/JP]; C/O Canon Kabushiki Kaisha 3-30-2,  
Shimomaruko, Ohta-ku, Tokyo, 1468501 (JP). MOR-  
ISHITA, Masakazu [JP/JP]; C/O Canon Kabushiki  
Kaisha 3-30-2, Shimomaruko, Ohta-ku, Tokyo, 1468501  
(JP). MOCHIZUKI, Chiori [JP/JP]; C/O Canon

Kabushiki Kaisha 3-30-2, Shimomaruko, Ohta-ku,  
Tokyo, 1468501 (JP). WATANABE, Minoru [JP/JP]; C/O  
Canon Kabushiki Kaisha 3-30-2, Shimomaruko, Ohta-ku,  
Tokyo, 1468501 (JP). ISHII, Takamasa [JP/JP]; C/O  
Canon Kabushiki Kaisha 3-30-2, Shimomaruko, Ohta-ku,  
Tokyo, 1468501 (JP).

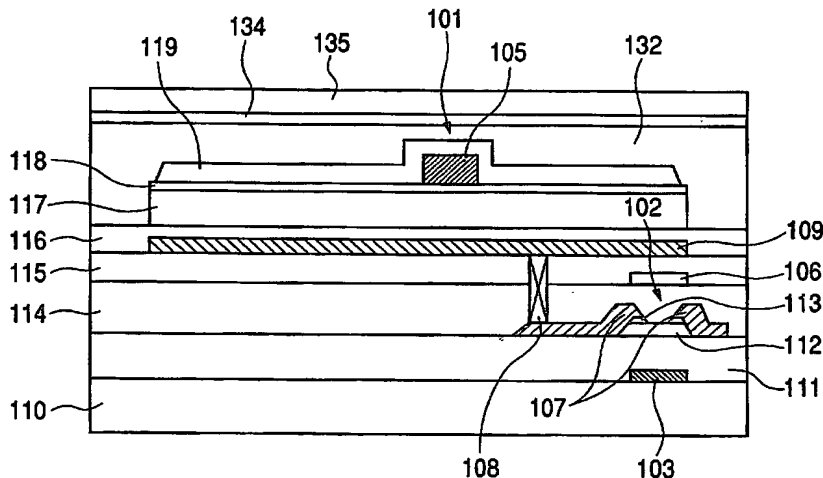
(74) Agents: OKABE, Masao et al.; No. 602, Fuji Bldg., 2-3,  
Marunouchi 3-chome, Chiyoda-ku, Tokyo, 1000005 (JP).

(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,  
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,  
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG,  
KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG,  
MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH,  
PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN,  
TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every  
kind of regional protection available): ARIPO (BW, GH,  
GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), Euro-  
pean (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR,

[Continued on next page]

(54) Title: SOLID-STATE IMAGE PICKUP DEVICE AND RADIATION IMAGE PICKUP DEVICE



(57) Abstract: A solid-state image pickup device according to the present invention has a plurality of photoelectric conversion elements and a plurality of switching elements, characterized in that the photoelectric conversion element is formed above at least one switching element, and a shielding electrode layer is disposed between the switching elements and the photoelectric conversion elements. Further, a radiation image pickup device according to the present invention has a radiation conversion layer for directly converting radiation into electric charges, and a plurality of switching elements, and is characterized in that the radiation conversion layer is formed above one or more switching elements, and a shielding electrode layer is disposed between the switching elements and the radiation conversion layer.

WO 2004/073067 A1



GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK,  
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,  
ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— *with international search report*

## DESCRIPTION

SOLID-STATE IMAGE PICKUP DEVICE AND  
RADIATION IMAGE PICKUP DEVICE

5

## TECHNICAL FIELD

The present invention relates in general to a radiation image pickup device for detecting radiation such as X-rays, alpha rays, beta rays, or gamma rays, the device being applied to a medical image diagnosis system, a non-destructive inspection system, an analyzer or the like. More particularly, the invention relates to a solid-state image pickup device for use in a flat panel detector (hereinafter referred to as "an FPD" for short when applicable). The FPD is obtained by combining a sensor array constituted by a sensor device using non-monocrystalline silicon, e.g., amorphous silicon (hereinafter referred to as "a-Si" for short) and TFT elements, with a phosphor for converting radiation into visible rays of light, etc.

10

15

20

## BACKGROUND ART

In recent years, the technique for TFTs for liquid crystal display devices has progressed, and servicing for information infrastructure has been made satisfactory. Thus, at the present time, the

25

FPD is proposed, and even in the medical image field, the FPD can have a large area and digitization of the FPD is attained.

This FPD is adapted to read out a radiation  
5 image in an instant to display the radiation image  
thus read out on a display device simultaneously, and  
an image can be directly fetched in the form of  
digital information from the FPD. Thus, the FPD has  
the feature that handling management is convenient in  
10 safekeeping of data, or process and transfer of data.  
In addition, it was verified that though the  
characteristics such as sensitivity depend on  
photographing conditions, the characteristics are  
equal to or superior to those in a conventional  
15 screen film photographing method or a computed  
radiography photographing method.

Commercialization of the FPD has been attained.  
On the other hand, various proposals for the FPD have  
been made for the purpose of aiming at further  
20 enhancing the sensitivity. For example, in a report  
made in a literature of L.E Antonuk et al.: "SPIE  
Medical Imaging VI", February, pp. 23 to 27, 1992,  
there is disclosed a structure in which a sensor  
element is formed on a TFT element. In this related  
25 art example, adoption of the above-mentioned  
structure allows an open area ratio of the sensor  
element to be increased to make enhancement of

sensitivity possible. In addition, it is described that since the TFT element is disposed right under the sensor element, an unnecessary parasitic capacity is formed, and hence a grounded plane is disposed.

5           In addition, in a proposal made in a literature of the specification in U.S. Patent No. 5,498,880 granted to DuPont, likewise, there is shown a structure in which in order to increase an open area ratio, a sensor element is formed on a TFT element.

10       In this related art example, there is adopted the structure in which an electrode connected to a source/drain electrode of the TFT covers the TFT element, and also becomes a separate electrode of the sensor element.

15           On the other hand, in a proposal as well in a literature of Japanese Patent Application Laid-Open No. 2000-156522 filed by Canon Kabushiki Kaisha, there is shown a structure in which for the purpose of aiming at increasing an open area ratio, a sensor

20       element is formed above a TFT element. In this related art example, there is adopted the structure in which the sensor element is formed over the TFT element through an interlayer film.

          However, in the above-mentioned FPD having the

25       structure in which the sensor element is formed on the TFT element, the separate electrode of the sensor element acts as a back gate electrode of the TFT

element. Hence, a problem such as generation of a leakage current of the TFT element is caused due to the fluctuation in electric potential of the separate electrode. Such a problem appears in the form of  
5 degradation of quality of an image.

In a case where for example, an area having a large sensor output signal, and an area having a small sensor output signal are disposed adjacent to each other, such crosstalk as to blur a boundary  
10 between these areas appears. In addition, there is caused a problem that a sensor saturation output is decreased to reduce a dynamic range.

#### DISCLOSURE OF THE INVENTION

15 The present invention has been made in the light of the foregoing problems, and it is, therefore, an object of the present invention to make it possible that even when an electric potential of a separate electrode of a sensor element disposed above  
20 a switching element fluctuates, the fluctuation in characteristics due to generation of a leakage current of the switching element is suppressed to attain enhancement of sensitivity.

In order to solve the above-mentioned problems,  
25 according to the present invention, there is provided a solid-state image pickup device including a plurality of photoelectric conversion elements and a

plurality of switching elements, characterized in that the photoelectric conversion element is formed above at least one switching element, and a shielding electrode layer is disposed between the switching  
5 elements and the photoelectric conversion elements.

Further, according to the present invention, there is provided a radiation image pickup device including a radiation conversion layer for directly converting radiation into electric charges, and a  
10 plurality of switching elements, characterized in that the radiation conversion layer is formed above one or more switching elements, and a shielding electrode layer is disposed between the switching elements and the radiation conversion layer.

15 According to the present invention, the shielding layer is provided so as to be interposed between the switching element and the sensor portion formed above the switching element, whereby even when an electric potential of a separate electrode of the  
20 sensor element disposed above the switching element fluctuates, the fluctuation in characteristics due to generation of a leakage current of the switching element can be suppressed to attain enhancement of sensitivity.

25 Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the

accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

## 5 BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve  
10 to explain the principles of the invention.

FIG. 1 is a schematic equivalent circuit diagram of pixels disposed in matrix of  $3 \times 3$  of a solid-state image pickup device according to Embodiment 1 of the present invention;

15 FIG. 2 is a schematic plan view of one pixel of the solid-state image pickup device according to Embodiment 1 of the present invention;

FIG. 3 is a schematic plan view of four pixels of the solid-state image pickup device according to  
20 Embodiment 1 of the present invention;

FIG. 4 is a schematic cross sectional view of the solid-state image pickup device according to Embodiment 1 of the present invention;

FIG. 5 is a schematic equivalent circuit  
25 diagram of pixels disposed in matrix of  $3 \times 3$  of a solid-state image pickup device according to Embodiment 2 of the present invention;



FIG. 6 is a schematic plan view of one pixel of the solid-state image pickup device according to Embodiment 2 of the present invention;

FIG. 7 is a schematic plan view of four pixels of the solid-state image pickup device according to Embodiment 2 of the present invention;

FIG. 8 is a schematic cross sectional view of the solid-state image pickup device according to Embodiment 2 of the present invention;

FIG. 9 is a schematic equivalent circuit diagram of pixels disposed in matrix of  $3 \times 3$  of a solid-state image pickup device according to Embodiment 3 of the present invention;

FIG. 10 is a schematic plan view of one pixel of the solid-state image pickup device according to Embodiment 3 of the present invention;

FIG. 11 is a schematic plan view of four pixels of the solid-state image pickup device according to Embodiment 3 of the present invention;

FIG. 12 is a schematic cross sectional view of the solid-state image pickup device according to Embodiment 3 of the present invention; and

FIG. 13 is a schematic cross sectional view of a radiation image pickup device according to Embodiment 4 of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Next, embodiments of the present invention will hereinafter be described with reference to the accompanying drawings.

#### Embodiment 1

5           Description will hereinafter be given with respect to a solid-state image pickup device using a MIS type photodiode (hereinafter referred to as "a PD" for short when applicable) according to Embodiment 1 of the present invention.

10           FIG. 1 is a schematic equivalent circuit diagram of pixels disposed in matrix of  $3 \times 3$  of a solid-state image pickup device according to Embodiment 1, FIG. 2 is a schematic plan view of one pixel of the solid-state image pickup device  
15 according to this embodiment, FIG. 3 is a schematic plan view of four pixels of the solid-state image pickup device according to this embodiment, and FIG. 4 is a schematic cross sectional view of the solid-state image pickup device according to this  
20 embodiment.

          In FIGS. 1 and 2, reference numeral 101 designates a MIS type PD as a photoelectric conversion element (sensor element); reference numeral 102 designates a transferring TFT as a  
25 switching element (thin film transistor); reference numeral 103 designates a transferring TFT driving wiring; reference numeral 104 designates a signal

line; reference numeral 105 designates a sensor  
biasing wiring; reference numeral 106 designates a  
shielding wiring (GND wiring); reference numeral 107,  
a source/drain electrode layer of the transferring  
5 TFT 102; reference numeral 108, a contact hole; and  
109, a sensor lower electrode layer.

In FIG. 4, reference numeral 110 designates an  
insulating substrate made of glass or the like;  
reference numeral 111 designates a gate insulating  
10 film made of SiN, SiO<sub>2</sub> or the like; reference numeral  
112 designates a first amorphous semiconductor layer  
made of a-Si or the like; reference numeral 113  
designates a first n<sup>+</sup> type layer (ohmic contact  
layer); reference numerals 114 and 115 each designate  
15 an interlayer insulating film made of SiN, SiO<sub>2</sub>,  
Benzocyclobutene (BCB), Polyimide (PI) or the like;  
reference numeral 116 designates an insulating film  
made of SiN, SiO<sub>2</sub> or the like; reference numeral 117,  
a second amorphous semiconductor layer made of a-Si  
20 or the like; reference numeral 118, a second n<sup>+</sup> type  
layer (hole blocking layer) made of microcrystalline  
silicon, a-Si or the like; reference numeral 119, a  
transparent electrode layer made of ITO, SnO<sub>2</sub> or the  
like; reference numeral 132, a passivation layer made  
25 of SiN, PI or the like; reference numeral 134, an  
adhesion layer; and 135, a phosphor layer acting as a  
wavelength conversion layer.

Note that, in FIG. 4, reference numerals 103, 105 and 106 designate a gate electrode layer, a sensor biasing electrode layer, and a shielding electrode layer, respectively.

5       The insulating film 116, the second amorphous semiconductor layer 117 made of a-Si or the like, and the second  $n^+$  type layer 118 constitute a photoelectric conversion layer of the MIS type PD 101. The gate electrode layer 103, the gate insulating  
10 film 111 made of SiN, SiO<sub>2</sub> or the like, the first amorphous semiconductor layer 112 made of a-Si or the like, the first  $n^+$  type layer (ohmic contact layer) 113, and the source/drain electrode layer 107 for the transferring TFT constitute the transferring TFT 102.  
15 The photoelectric conversion layer is formed above the transferring TFT 102, and hence the transferring TFT 102 is covered with the photoelectric conversion layer.

20       The shielding electrode layer 106 is disposed so as to be interposed between the MIS type PD 101 and the transferring TFT 102.

      Radiation such as X-rays is made incident from an upper side in the paper of FIG. 2 to be converted into visible rays of light through the phosphor layer  
25 135. The resultant rays are then converted into electric charges by the MIS type PD 101 to be accumulated in the MIS type PD 101. Thereafter, the

transferring TFT 102 is operated by a TFT driving circuit through the transferring TFT driving wiring 103 to transfer these accumulated electric charges to the signal line 104 connected to one of the source electrode and the drain electrode of the transferring TFT 102 to be processed in the signal processing circuit, and the resultant analog signal is then subjected to A/D conversion in the A/D conversion circuit to be outputted. At this time, an electric potential of the shielding wiring 106 is fixed to a constant electric potential such as GND at all times.

In this embodiment, the shielding wiring 106 disposed below the sensor element is grounded. As a result, even if an electric potential of a separate electrode of the sensor element fluctuates, the fluctuation in characteristics due to generation of a leakage current of the TFT element can be suppressed to allow enhancement of sensitivity to be attained. In addition, since the shielding wiring 106 does not overlap the signal line 104 at all, no parasitic capacity is formed between the shielding wiring 106 and the signal line 104, and hence degradation of the sensor sensitivity can also be suppressed.

In this embodiment, there has been shown the specific case where a width of the shielding wiring 106 is identical to a channel width of the TFT. However, in order to reduce a capacity in a cross

portion between the transferring TFT driving wiring 103 and the shielding wiring 106, it is also possible to use a wiring having a width smaller than the channel width in the cross portion between the transferring TFT driving wiring 103 and the shielding wiring 106.

In addition, the shielding wiring 106 has only to be held at a constant electric potential, and hence it is also possible to set the electric potential of the shielding wiring 106 to any constant electric potential other than GND. Since a resistance of the shielding wiring 106 may be high, a wiring made of a high melting point metal such as molybdenum (Mo), chromium (Cr), titanium (Ti), tungsten (W), or molybdenum-tungsten (MoW) can be used as the shielding wiring 106. As a result, a limitation to a manufacturing process can be reduced. Moreover, of the layer including the gate electrode, the layer including the source/drain electrode, the layer including the shielding electrode, and the layer including the sensor biasing electrode, the shielding electrode layer is formed as the thinnest wiring to reduce a difference in level and to reduce a difference in level of the sensor portion formed above the shielding wiring 106, resulting in improving the yield. This is because an electrical resistance value of the shielding electrode layer may

be larger than that of each of other electrode layers.

## Embodiment 2

Description will hereinafter be given with respect to a solid-state image pickup device using a MIS type PD according to Embodiment 2 of the present invention.

FIG. 5 is a schematic equivalent circuit diagram of pixels disposed in matrix of  $3 \times 3$  of a solid-state image pickup device according to Embodiment 2, FIG. 6 is a schematic plan view of one pixel of the solid-state image pickup device according to this embodiment, FIG. 7 is a schematic plan view of four pixels of the solid-state image pickup device according to this embodiment, and FIG. 8 is a schematic cross sectional view of the solid-state image pickup device according to this embodiment.

The same reference numerals as those in Embodiment 1 indicate the same components.

In FIGS. 5 and 6, reference numeral 101 designates a MIS type PD; reference numeral 102 designates a transferring TFT; reference numeral 103 designates a transferring TFT driving wiring; reference numeral 104 designates a signal line; reference numeral 105 designates a sensor biasing wiring; reference numeral 106 designates a shielding wiring (GND wiring); reference numeral 108, a contact

hole; reference numeral 109, a sensor lower electrode layer; reference numeral 120, a resetting TFT as a switching element; reference numeral 121, a resetting TFT driving wiring; and 126, a reset wiring.

5           In FIG. 8, reference numeral 110 designates an insulating substrate made of glass or the like; reference numeral 111 designates a gate insulating film made of SiN, SiO<sub>2</sub> or the like; reference numeral 112 designates a first amorphous semiconductor layer  
10 made of a-Si or the like; reference numeral 113 designates a first n<sup>+</sup> type layer (ohmic contact layer); reference numerals 114 and 115 each designate an interlayer insulating film made of SiN, SiO<sub>2</sub>, Benzocyclobutene (BCB), Polyimide (PI) or the like;  
15 reference numeral 116 designates an insulating film made of SiN, SiO<sub>2</sub> or the like; reference numeral 117, a second amorphous semiconductor layer made of a-Si or the like; reference numeral 118, a second n<sup>+</sup> type layer (hole blocking layer) made of microcrystalline  
20 silicon, a-Si or the like; reference numeral 119, a transparent electrode layer made of ITO, SnO<sub>2</sub> or the like; reference numeral 107, a source/drain electrode layer of the transferring TFT 102; reference numeral 122, a source/drain electrode layer of the resetting  
25 TFT; reference numeral 132, a passivation layer made of SiN, PI or the like; reference numeral 134, an adhesion layer; and 135, a phosphor layer.



Note that, in FIG. 8, reference numerals 103 and 121 each designate a gate electrode layer, reference numeral 105 designates a sensor biasing electrode layer, and reference numeral 106 designates a shielding electrode layer.

The insulating film 116, the second amorphous semiconductor layer 117 made of a-Si or the like, and the second  $n^+$  type layer 118 constitute a photoelectric conversion layer of the MIS type PD 101.

10 The gate electrode layer 103, the gate insulating film 111 made of SiN, SiO<sub>2</sub> or the like, the first amorphous semiconductor layer 112 made of a-Si or the like, the first  $n^+$  type layer (ohmic contact layer) 113, and the source/drain electrode layer 107 for the

15 transferring TFT constitute the transferring TFT 102. The gate electrode layer 121, the gate insulating film 111 made of SiN, SiO<sub>2</sub> or the like, the first amorphous semiconductor layer 112 made of a-Si or the like, the first  $n^+$  type layer (ohmic contact layer)

20 113, and the source/drain electrode layer 122 of the resetting TFT constitute the resetting TFT 120. The photoelectric conversion layer is formed above the transferring TFT 102 and the resetting TFT 120, and hence both the TFTs are covered with the

25 photoelectric conversion layer.

The shielding electrode layer 106 is disposed so as to be interposed between the MIS type PD 101

and the transferring TFT 102, and between the MIS type PD 101 and the resetting TFT 120.

Radiation such as X-rays is made incident from an upper side in the paper of FIG. 6 to be converted into visible rays of light through the phosphor layer 135. The resultant rays are then converted into electric charges by the MIS type PD 101 to be accumulated in the MIS type PD 101. Thereafter, the transferring TFT 102 is operated by the transferring TFT driving wiring 103 connected to a TFT driving circuit to transfer these accumulated electric charges to the signal line 104 connected to one of the source electrode and the drain electrode of the transferring TFT 102 to be processed in the signal processing circuit, and the resultant analog signal is then subjected to A/D conversion in the A/D conversion circuit to be outputted. Thereafter, the resetting TFT 120 is operated by the resetting TFT driving wiring 121 connected to the signal processing circuit to reset the MIS type PD 101. At this time, an electric potential of the shielding wiring 106 is fixed to a constant electric potential such as GND at all times.

In this embodiment, the shielding wiring 106 disposed below the sensor element is grounded. As a result, even if an electric potential of a separate electrode of the sensor element fluctuates, the

fluctuation in characteristics due to generation of a leakage current of the TFT element can be suppressed to allow enhancement of sensitivity to be attained. In addition, since the shielding wiring 106 does not  
5 overlap the signal line 104 at all, no parasitic capacity is formed between the shielding wiring 106 and the signal line 104, and hence degradation of the sensor sensitivity can also be suppressed.

In this embodiment, there has been shown the  
10 specific case where a width of the shielding wiring 106 is identical to a channel width of the TFT. However, in order to reduce a capacity in a cross portion between the respective TFT driving wirings, it is also possible to use a wiring having a width  
15 smaller than the channel width in the cross portion between the respective TFT driving wirings.

#### Embodiment 3

Description will hereinafter be given with respect to a solid-state image pickup device using a  
20 MIS type PD according to Embodiment 3 of the present invention.

FIG. 9 is a schematic equivalent circuit diagram of pixels disposed in matrix of  $3 \times 3$  of a solid-state image pickup device according to  
25 Embodiment 3, FIG. 10 is a schematic plan view of one pixel of the solid-state image pickup device according to this embodiment, FIG. 11 is a schematic

plan view of four pixels of the solid-state image pickup device according to this embodiment, and FIG. 12 is a schematic cross sectional view of the solid-state image pickup device according to this  
5 embodiment.

The same reference numerals as those in Embodiment 1 indicate the same components.

In FIGS. 9 and 10, reference numeral 101 designates a MIS type PD; reference numeral 104  
10 designates a signal line; reference numeral 105 designates a sensor biasing wiring; reference numeral 106 designates a shielding wiring (GND wiring); reference numeral 108 designates a contact hole; reference numeral 109 designates a sensor lower  
15 electrode; reference numeral 120 designates a resetting TFT; reference numeral 121 designates a resetting TFT driving wiring; reference numeral 123, a storage capacitor; reference numerals 124 and 125 designate a switching TFT and a reading TFT forming a  
20 source follower (SFA), respectively; reference numeral 126, a reset wiring; reference numeral 127, a contact hole through which the storage capacitor 123 and the shielding wiring 106 are connected to each other; reference numeral 128, a switching TFT driving  
25 wiring; and 130, a reading TFT driving electrode.

FIG. 12 is a schematic cross sectional view showing a part of the solid-state image pickup device

indicated by an arrow in FIG. 10. Reference numeral 110 designates an insulating substrate made of glass or the like; reference numeral 111 designates a gate insulating film made of SiN, SiO<sub>2</sub> or the like;

5 reference numeral 112 designates a first amorphous semiconductor layer made of a-Si or the like; reference numeral 113 designates a first n<sup>+</sup> type layer (ohmic contact layer); reference numerals 114 and 115 each designate an interlayer insulating film

10 made of SiN, SiO<sub>2</sub>, Benzocyclobutene (BCB), Polyimide (PI) or the like; reference numeral 116 designates an insulating film made of SiN, SiO<sub>2</sub> or the like; reference numeral 117, a second amorphous semiconductor layer made of a-Si or the like;

15 reference numeral 118, a second n<sup>+</sup> type layer (hole blocking layer) made of microcrystalline silicon, a-Si or the like; reference numeral 119, a transparent electrode layer made of ITO, SnO<sub>2</sub> or the like; reference numeral 122, a source/drain electrode layer

20 of the resetting TFT; reference numeral 129, a source/drain electrode layer of the switching TFT; reference numeral 131, a source/drain electrode layer of the reading TFT; reference numeral 132, a passivation layer made of SiN, PI or the like;

25 reference numeral 133, a contact hole; reference numeral 134, an adhesion layer; and 135, a phosphor layer.

Note that, in FIG. 12, reference numerals 121, 128, and 130 each designate a gate electrode layer, reference numeral 105 designates a sensor biasing electrode layer, and reference numeral 106 designates a shielding electrode layer.

The insulating film 116, the second amorphous semiconductor layer 117, and the second  $n^+$  type layer 118 constitute a photoelectric conversion layer of the MIS type PD 101. The gate electrode layer 121, the gate insulating film 111 made of SiN, SiO<sub>2</sub> or the like, the first amorphous semiconductor layer 112 made of a-Si or the like, the first  $n^+$  type layer (ohmic contact layer) 113, and the source/drain electrode layer 122 for the resetting TFT constitute the resetting TFT 120. The gate electrode layer 128, the gate insulating film 111 made of SiN, SiO<sub>2</sub> or the like, the first amorphous semiconductor layer 112 made of a-Si or the like, the first  $n^+$  type layer (ohmic contact layer) 113, and the source/drain electrode layer 129 of the switching TFT constitute the switching TFT 124. The photoelectric conversion layer is formed above the resetting TFT 120 and the switching TFT 124, and hence both the TFTs are covered with the photoelectric conversion layer.

The shielding electrode layer 106 is disposed so as to be interposed between the MIS type PD 101 and the resetting TFT 120, and between the MIS type

PD 101 and the switching TFT 124.

Radiation such as X-rays is made incident from an upper side in the paper of FIG. 10 to be converted into visible rays of light through the phosphor layer

5 135. The resultant rays are then converted into electric charges by the MIS type PD 101 to be accumulated in the storage capacitor 123 through the contact holes 108 and 133. Fluctuation in electric potential corresponding to these accumulated electric

10 charges is caused in the gate electrode of the reading TFT 125. Thereafter, the switching TFT 124 is operated through the switching TFT driving wiring 128 so that the accumulated electric charges are read out through the signal line 104 connected to one of

15 the source electrode and the drain electrode of the reading TFT 125 to be processed in the signal processing circuit. The resultant analog signal is then subjected to A/D conversion in an A/D conversion circuit to be outputted. Thereafter, the resetting

20 TFT 120 is operated through the resetting TFT driving wiring 121 connected to the signal processing circuit to reset the storage capacitor 123. At this time, an electric potential of the shielding wiring 106 is fixed to a constant electric potential such as GND at

25 all times.

In this embodiment, the shielding wiring 106 disposed below the sensor element is grounded. As a

result, even if an electric potential of a separate electrode of the sensor element fluctuates, the fluctuation in characteristics due to generation of a leakage current of the TFT element can be suppressed to allow enhancement of sensitivity to be attained. In addition, since the shielding wiring 106 does not overlap the signal line 104 at all, no parasitic capacity is formed between the shielding wiring 106 and the signal line 104, and hence degradation of the sensor sensitivity can also be suppressed.

In this embodiment, there has been shown the specific case where the shielding wiring portion is disposed above the two TFT portions and the storage capacitor portion. However, it is also possible to dispose the shielding wiring portion above three TFT portions and the storage capacitor portion.

In each of the embodiments 1 to 3 of the present invention described above, there has been shown the specific case where in the indirect type solid-state image pickup device, the MIS type PD is used as the photoelectric conversion element. However, it is also possible to use a PIN type PD. In case of the PIN type PD, the photoelectric conversion layer includes a  $p^+$  type layer, a second amorphous semiconductor layer, and a second  $n^+$  type layer instead of the insulating film 116, the second amorphous semiconductor layer 117, and the second  $n^+$



type layer 118, respectively.

#### Embodiment 4

Description will hereinafter be given with respect to a direct type radiation image pickup device according to Embodiment 4 of the present invention.

FIG. 13 is a schematic cross sectional view of a direct type radiation image pickup device. Reference numeral 110 designates an insulating substrate made of glass or the like; reference numeral 111 designates a gate insulating film made of SiN, SiO<sub>2</sub> or the like; reference numeral 112 designates a first amorphous semiconductor layer made of a-Si or the like; reference numeral 113 designates an n<sup>+</sup> type layer (ohmic contact layer); reference numerals 114 and 115 each designate an interlayer insulating film made of SiN, SiO<sub>2</sub>, Benzocyclobutene (BCB), Polyimide (PI) or the like; reference numeral 120 designates a resetting TFT; reference numeral 123 designates a storage capacitor; reference numerals 124 and 125 designate a switching TFT and a reading TFT forming a source follower (SFA), respectively; reference numeral 121 designates a resetting TFT driving wiring; reference numeral 122, a source/drain electrode layer of the resetting TFT; reference numeral 129, a source/drain electrode layer of the switching TFT; reference numeral 128, a switching TFT

driving wiring; reference numeral 130, a reading TFT driving electrode; reference numeral 131, a source/drain electrode layer of the reading TFT; reference numeral 132, a passivation layer made of SiN, PI or the like; reference numeral 133, a contact hole; and reference numeral 145, a radiation conversion layer for directly converting radiation into electric charges.

A circuit diagram of the radiation image pickup device shown in FIG. 13 is the same as that of FIG. 1 except that the radiation conversion layer 145 is used instead of the MIS type photodiode 101. In the direct type radiation image pickup device, a-Se, GaAs, CdTe or the like is used as a material of the radiation conversion layer.

Note that, in FIG. 13, reference numerals 121, 128 and 130 each designate a gate electrode layer, reference numeral 105 designates a sensor biasing electrode layer, and reference numeral 106 designates a shielding electrode layer.

A layer structure of the resetting TFT 120 and the reading TFT 124 is the same as that in Embodiment 3. The radiation conversion layer 145 is formed above the resetting TFT 120 and the reading TFT 124, and hence both the TFTs 120 and 124 are covered with the radiation conversion layer 145.

Further, the shielding electrode layer 106 is

disposed so as to be interposed between the radiation conversion layer 145 and the resetting TFT 120, and between the radiation conversion layer 145 and the switching TFT 124.

5           Radiation such as X-rays is made incident from an upper side of the radiation conversion layer shown in FIG. 13 to be directly converted into electric charges through the radiation conversion layer 145. The resultant electric charges are then accumulated  
10 in the storage capacitor 123 through the contact holes 108 and 133. Fluctuation in electric potential corresponding to the accumulated electric charges is caused in the gate electrode of the reading TFT 125. Thereafter, the switching TFT 124 is operated through  
15 the switching driving wiring 128 so that the accumulated electric charges are read out through the signal line 104 connected to one of the source electrode and the drain electrode of the reading TFT 125 to be processed in a signal processing circuit.  
20 The resultant analog signal is then subjected to A/D conversion in an A/D conversion circuit to be outputted. Thereafter, the resetting TFT 120 is operated through the resetting TFT driving wiring 121 connected to the signal processing circuit to reset  
25 the storage capacitor 123. At this time, an electric potential of the shielding wiring 106 is fixed to a constant electric potential such as GND at all times.

While above, the embodiments of the present invention have been described, preferred embodiment modes of the present invention will now be enumerated as follows.

5 Embodiment Mode 1

A solid-state image pickup device including a plurality of photoelectric conversion elements and a plurality of switching elements, characterized in that the photoelectric conversion element is formed  
10 above at least one switching element, and a shielding electrode layer is disposed between the switching elements and the photoelectric conversion elements.

Embodiment Mode 2

A solid-state image pickup device according to  
15 Embodiment Mode 1, characterized in that one photoelectric conversion element and one or more switching elements are disposed in one pixel.

Embodiment Mode 3

A solid-state image pickup device according to  
20 Embodiment Mode 1 or 2, characterized in that the photoelectric conversion element has a photoelectric conversion layer, and the photoelectric conversion layer includes an insulating layer, a semiconductor layer, and a high impurity concentrated semiconductor  
25 layer.

Embodiment Mode 4

A solid-state image pickup device according to

Embodiment Mode 1 or 2, characterized in that the photoelectric conversion element has a photoelectric conversion layer, and the photoelectric conversion layer includes a first high impurity concentrated semiconductor layer of one conductivity type, a  
5 semiconductor layer, and a second high impurity concentrated semiconductor layer of a conductivity type opposite to the one conductivity type of the first high impurity concentrated semiconductor layer.

10 Embodiment Mode 5

A solid-state image pickup device according to any one of Embodiment Modes 1 to 4, characterized in that the shielding electrode layer is not formed above a signal line connected to one of a source  
15 electrode and a drain electrode of the switching element.

Embodiment Mode 6

A solid-state image pickup device according to any one of Embodiment Modes 1 to 5, characterized in  
20 that the shielding electrode layer is held at a constant electric potential.

Embodiment Mode 7

A solid-state image pickup device according to Embodiment Mode 6, characterized in that the  
25 shielding electrode layer is grounded.

Embodiment Mode 8

A solid-state image pickup device according to

any one of Embodiment Modes 1 to 7, characterized in that each of the switching elements is constituted by a TFT, and the shielding electrode layer is disposed so as to cover an upper portion of a channel of each of the TFTs.

#### Embodiment Mode 9

A solid-state image pickup device according to Embodiment Mode 8, characterized in that the shielding electrode layer has a width equal to or smaller than a channel width of the TFT and is disposed so as to cross a TFT driving wiring.

#### Embodiment Mode 10

A solid-state image pickup device according to any one of Embodiment Modes 1 to 9, characterized in that the shielding electrode layer is made of a high melting point metal.

#### Embodiment Mode 11

A solid-state image pickup device according to Embodiment Mode 10, characterized in that the shielding electrode layer is made of molybdenum (Mo), chromium (Cr), titanium (Ti), tungsten (W), or molybdenum-tungsten (MoW).

#### Embodiment Mode 12

A solid-state image pickup device according to Embodiment Mode 1, characterized in that the shielding electrode layer is an electrode layer thinner than each of a gate electrode layer, a

source/drain electrode layer, and a sensor biasing electrode layer.

#### Embodiment Mode 13

A solid-state image pickup device according to  
5 Embodiment Mode 1, characterized in that the solid-state image pickup device includes a gate electrode layer, a gate insulating layer, a first amorphous semiconductor layer, a first n type semiconductor layer, a source/drain electrode layer, a first  
10 interlayer insulating layer, the shielding electrode layer, a second interlayer insulating layer, a sensor lower electrode layer, an insulating layer, a second amorphous semiconductor layer, a second n type semiconductor layer, a transparent electrode layer,  
15 and a sensor biasing electrode layer.

#### Embodiment Mode 14

A solid-state image pickup device according to Embodiment Mode 13, characterized in that one photoelectric conversion element and one or more TFTs  
20 are disposed in one pixel.

#### Embodiment Mode 15

A radiation image pickup device, characterized in that a wavelength conversion unit is disposed above the photoelectric conversion element in the  
25 solid-state image pickup device as described in any one of Embodiment Modes 1 to 9.

#### Embodiment Mode 16

A radiation image pickup device according to Embodiment Mode 15, characterized in that one photoelectric conversion element and one or more switching elements are disposed in one pixel.

5 Embodiment Mode 17

A radiation image pickup device including a radiation conversion layer for directly converting radiation into electric charges, and a plurality of switching elements, characterized in that the  
10 radiation conversion layer is formed above one or more switching elements, and a shielding electrode layer is disposed between the switching elements and the radiation conversion layer.

Embodiment Mode 18

15 A radiation image pickup device according to Embodiment Mode 17, characterized in that the radiation image pickup device includes a gate electrode layer, a gate insulating layer, a first amorphous semiconductor layer, a first n type  
20 semiconductor layer, a source/drain electrode layer, a first interlayer insulating layer, the shielding electrode layer, a second interlayer insulating layer, a sensor lower electrode layer, a radiation conversion layer, and a sensor biasing electrode  
25 layer.

As set forth hereinabove, according to the present invention, even if fluctuation in electric



potential of the separate electrode of the sensor element is caused, the fluctuation in characteristics due to generation of a leakage current of the switching element can be suppressed by provision of the shielding wiring disposed below the sensor element to allow enhancement of sensitivity to be attained. Moreover, since the shielding wiring does not overlap the signal line at all, a parasitic capacity formed between the shielding wiring and the signal line can be reduced to allow the degradation as well of the sensor sensitivity to be suppressed.

In addition, the shielding wiring having the width smaller than the channel width is used in the cross portion between the shielding wiring and the driving wiring of the switching element is used to allow the gate wiring capacity as well to be reduced.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the claims.

## CLAIMS

1. A solid-state image pickup device comprising a plurality of photoelectric conversion elements and a plurality of switching elements, characterized in  
5 that the photoelectric conversion element is formed above at least one switching element, and a shielding electrode layer is disposed between the switching elements and the photoelectric conversion elements.

2. A solid-state image pickup device according  
10 to claim 1, wherein one photoelectric conversion element and one or more switching elements are disposed in one pixel.

3. A solid-state image pickup device according to claim 1 or 2, wherein the photoelectric conversion  
15 element has a photoelectric conversion layer, and the photoelectric conversion layer includes an insulating layer, a semiconductor layer, and a high impurity concentrated semiconductor layer.

4. A solid-state image pickup device according  
20 to claim 1 or 2, wherein the photoelectric conversion element has a photoelectric conversion layer, and the photoelectric conversion layer includes a first high impurity concentrated semiconductor layer of one conductivity type, a semiconductor layer, and a  
25 second high impurity concentrated semiconductor layer of a conductivity type opposite to the one conductivity type of the first high impurity

concentrated semiconductor layer.

5. A solid-state image pickup device according to any one of claims 1 to 4, wherein the shielding electrode layer is not formed above a signal line  
5 connected to one of a source electrode and a drain electrode of the switching element.

6. A solid-state image pickup device according to any one of claims 1 to 5, wherein the shielding electrode layer is held at a constant electric  
10 potential.

7. A solid-state image pickup device according to claim 6, wherein the shielding electrode layer is grounded.

8. A solid-state image pickup device according  
15 to any one of claims 1 to 7, wherein each of the switching elements is constituted by a TFT, and the shielding electrode layer is disposed so as to cover an upper portion of a channel of each of the TFTs.

9. A solid-state image pickup device according  
20 to claim 8, wherein the shielding electrode layer has a width equal to or smaller than a channel width of the TFT and is disposed so as to cross a TFT driving wiring.

10. A solid-state image pickup device according  
25 to any one of claims 1 to 9, wherein the shielding electrode layer is made of a high melting point metal.

11. A solid-state image pickup device according

to claim 10, wherein the shielding electrode layer is made of molybdenum (Mo), chromium (Cr), titanium (Ti), tungsten (W), or molybdenum-tungsten (MoW).

12. A solid-state image pickup device according to claim 1, wherein the shielding electrode layer is an electrode layer thinner than each of a gate electrode layer, a source/drain electrode layer, and a sensor biasing electrode layer.

13. A solid-state image pickup device according to claim 1, wherein the solid-state image pickup device includes a gate electrode layer, a gate insulating layer, a first amorphous semiconductor layer, a first n type semiconductor layer, a source/drain electrode layer, a first interlayer insulating layer, the shielding electrode layer, a second interlayer insulating layer, a sensor lower electrode layer, an insulating layer, a second amorphous semiconductor layer, a second n type semiconductor layer, a transparent electrode layer, and a sensor biasing electrode layer.

14. A solid-state image pickup device according to claim 13, wherein one photoelectric conversion element and one or more TFTs are disposed in one pixel.

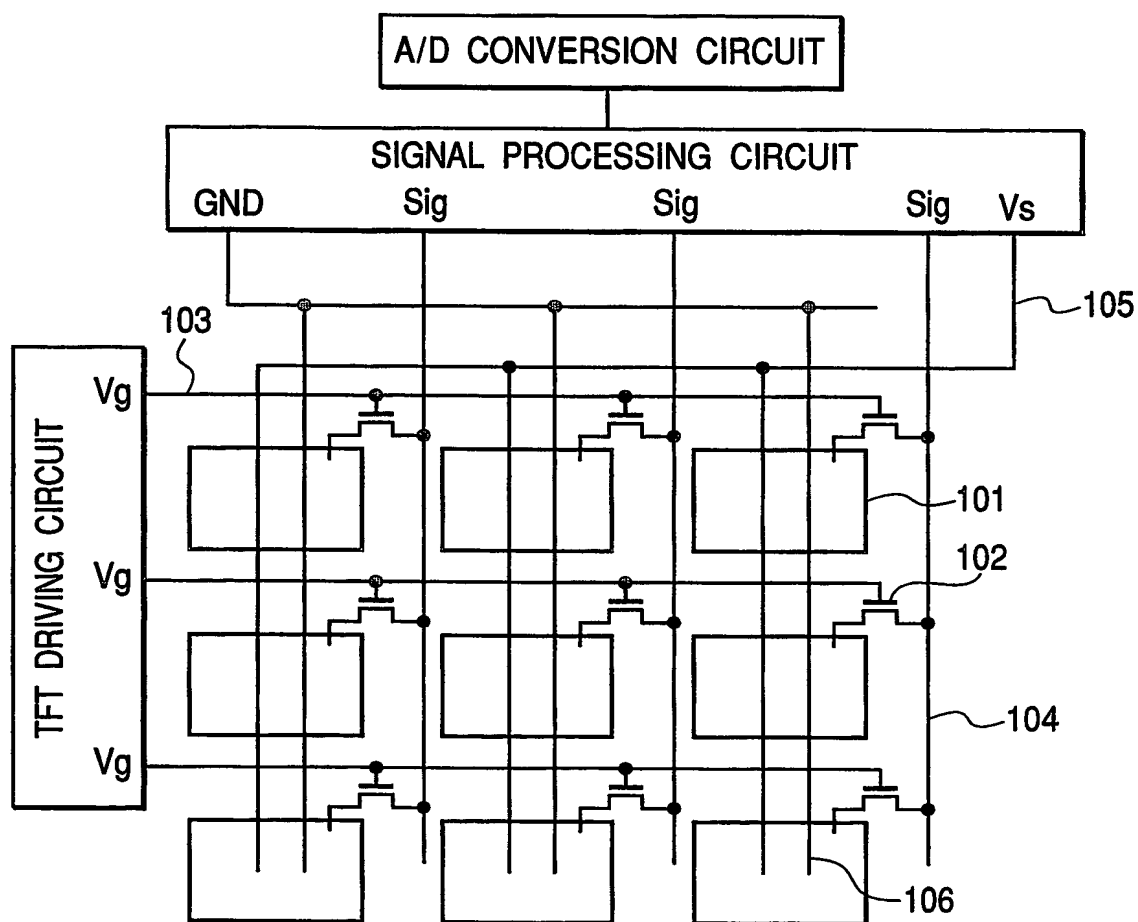
15. A radiation image pickup device, characterized in that a wavelength conversion unit is disposed above the photoelectric conversion element

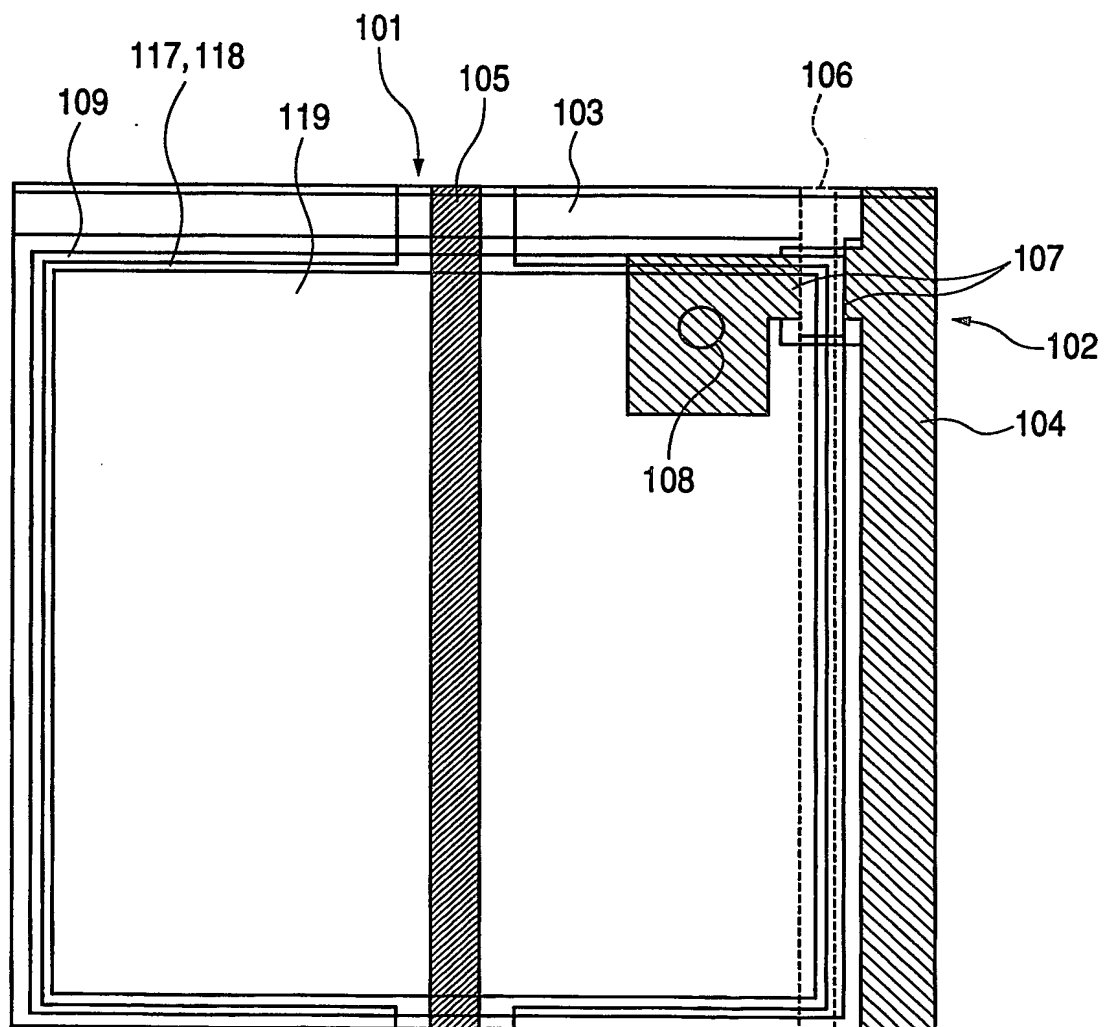
in the solid-state image pickup device as claimed in any one of claims 1 to 9.

16. A radiation image pickup device according to claim 15, wherein one photoelectric conversion element and one or more switching elements are disposed in one pixel.

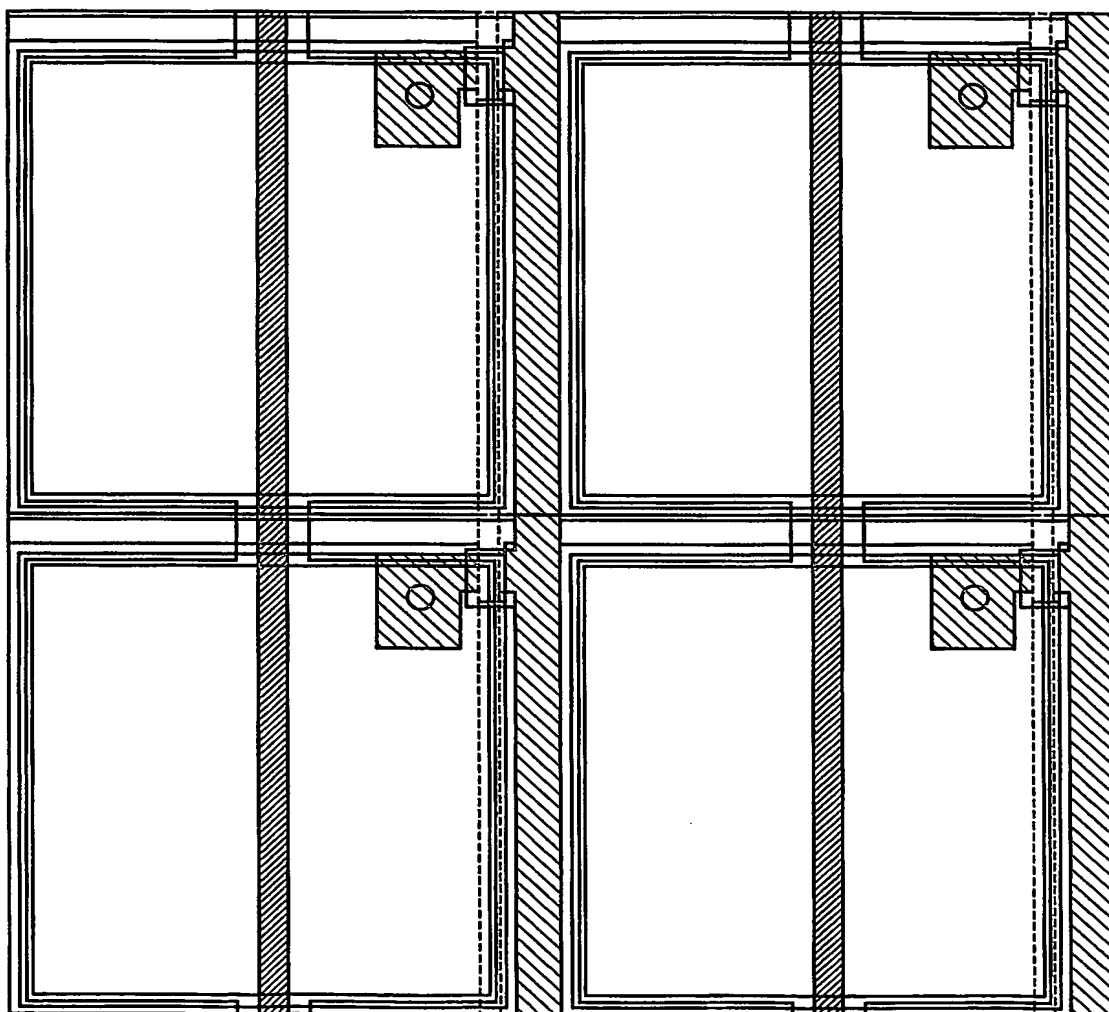
17. A radiation image pickup device comprising a radiation conversion layer for directly converting radiation into electric charges, and a plurality of switching elements, characterized in that the radiation conversion layer is formed above one or more switching elements, and a shielding electrode layer is disposed between the switching elements and the radiation conversion layer.

18. A radiation image pickup device according to claim 17, wherein the radiation image pickup device includes a gate electrode layer, a gate insulating layer, a first amorphous semiconductor layer, a first n type semiconductor layer, a source/drain electrode layer, a first interlayer insulating layer, the shielding electrode layer, a second interlayer insulating layer, a sensor lower electrode layer, a radiation conversion layer, and a sensor biasing electrode layer.

**FIG. 1**

**FIG. 2**

*FIG. 3*





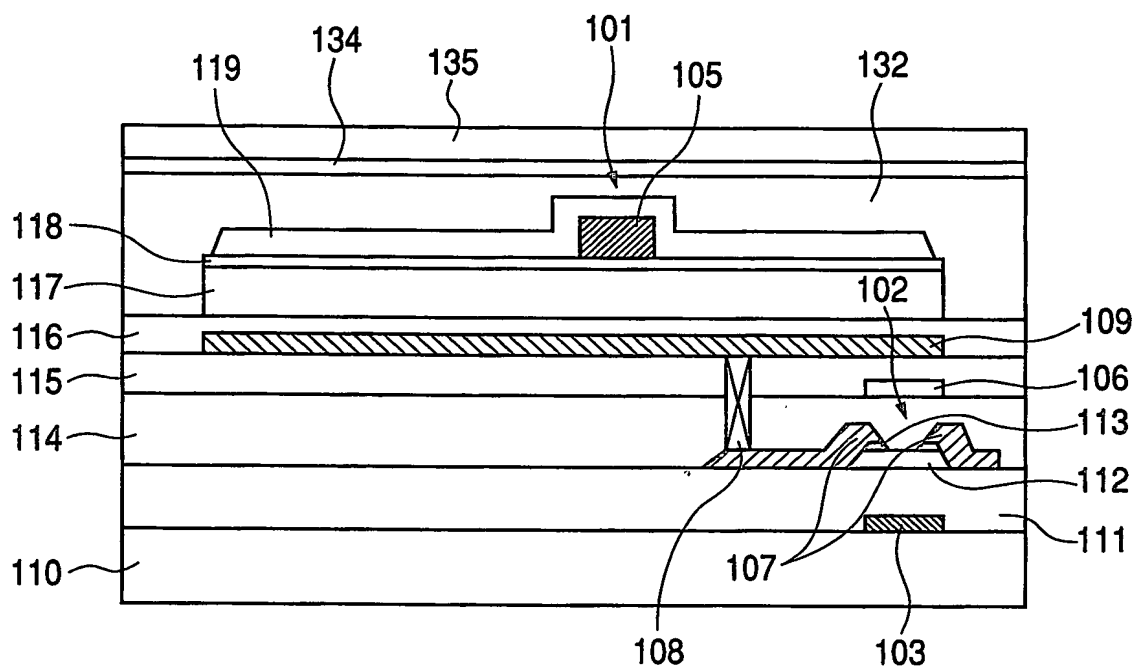
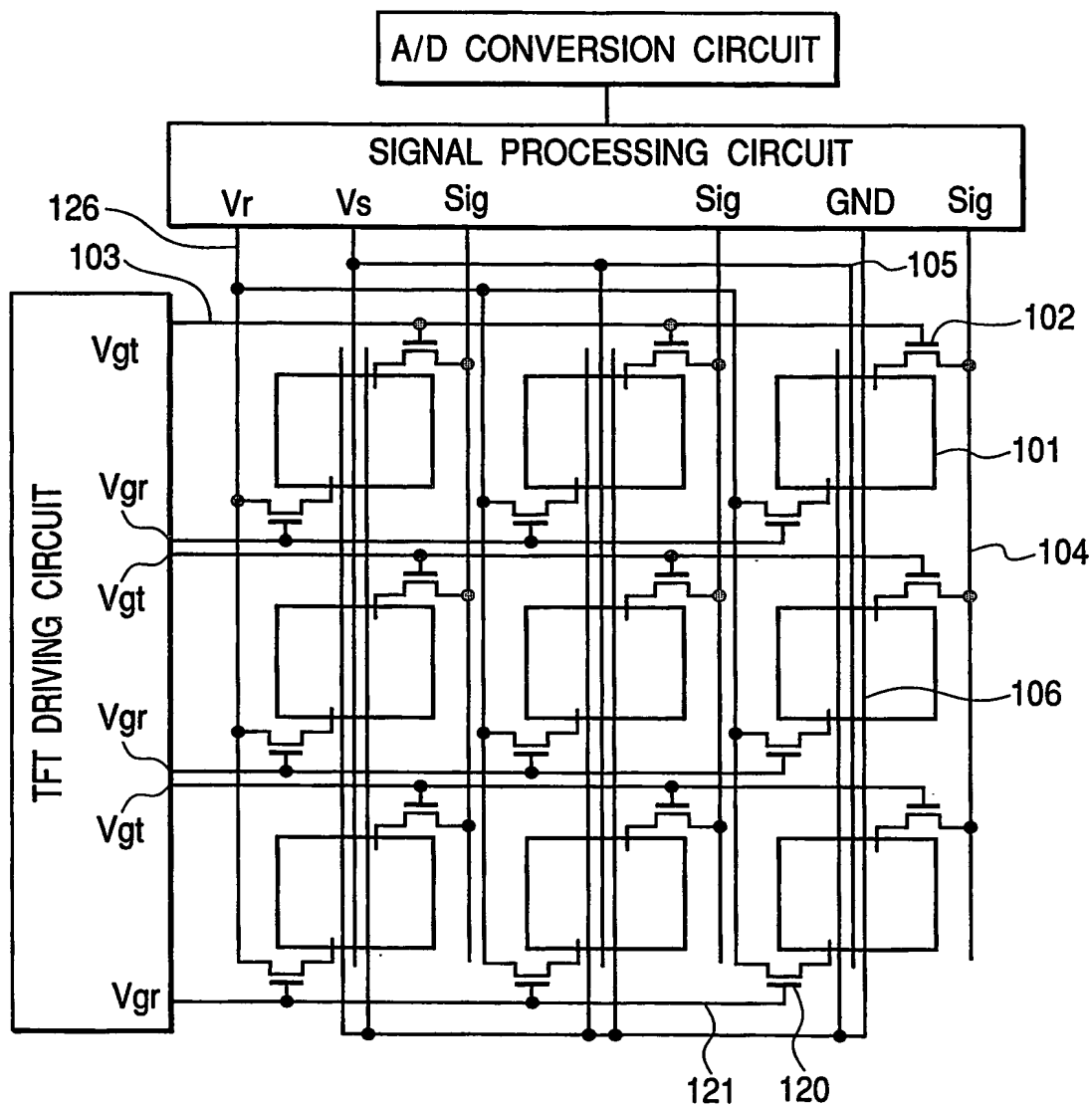
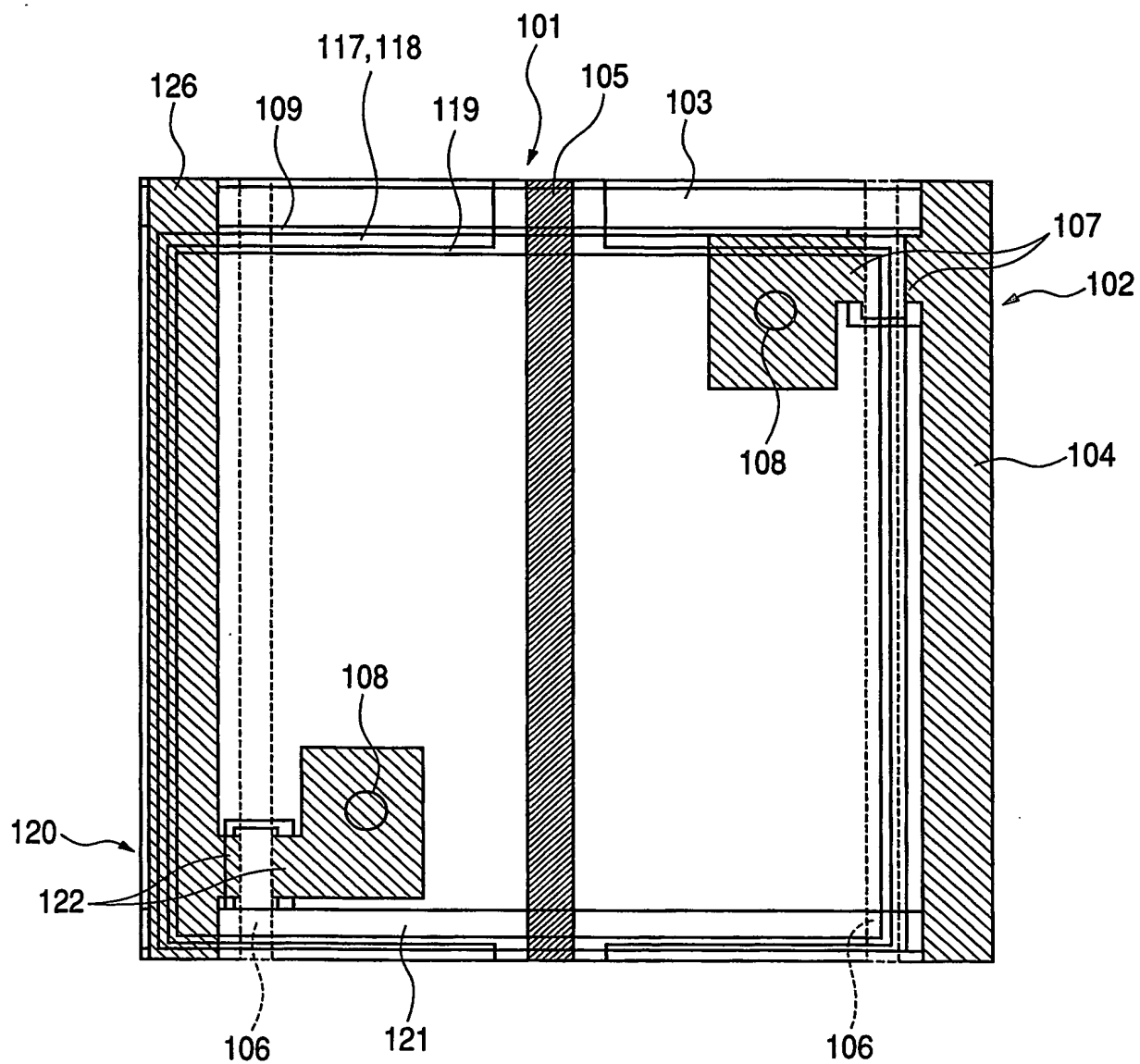
*FIG. 4*

FIG. 5



**FIG. 6**



7 / 13

*FIG. 7*

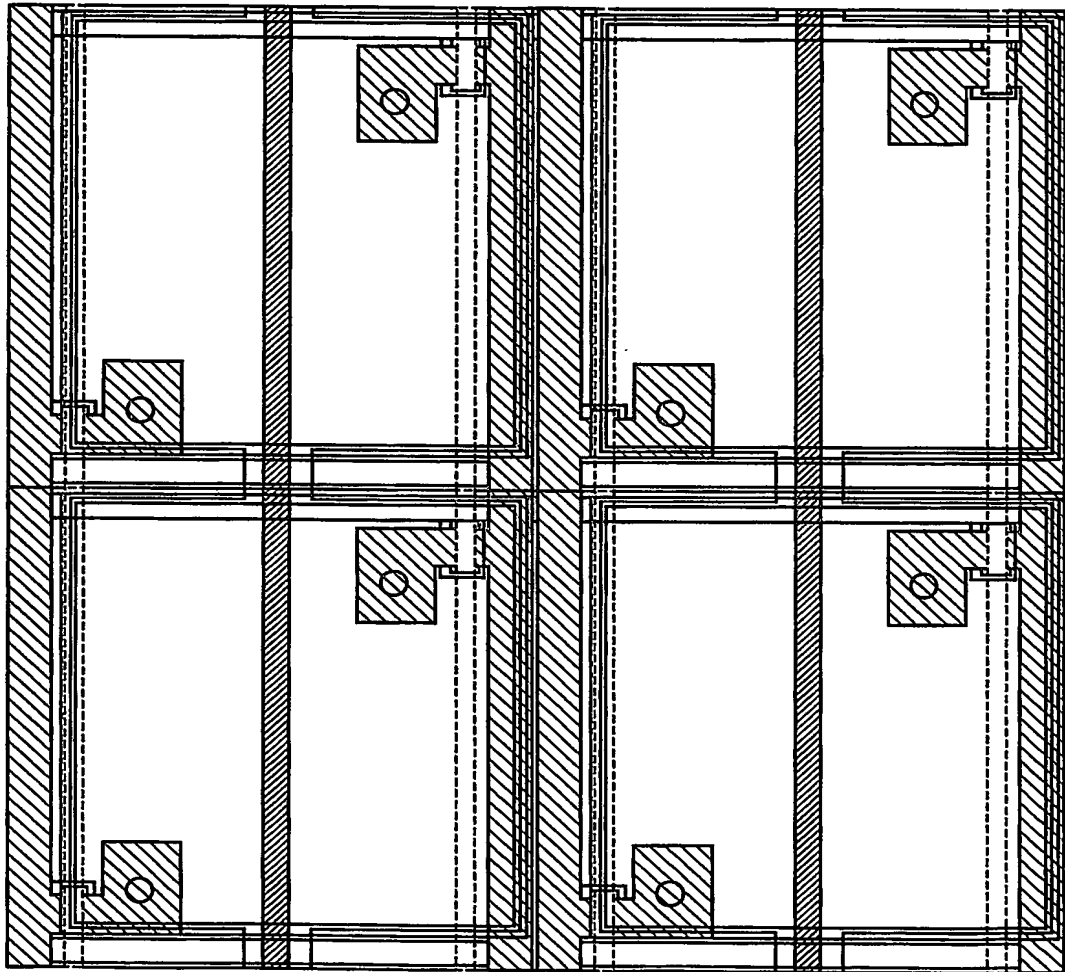
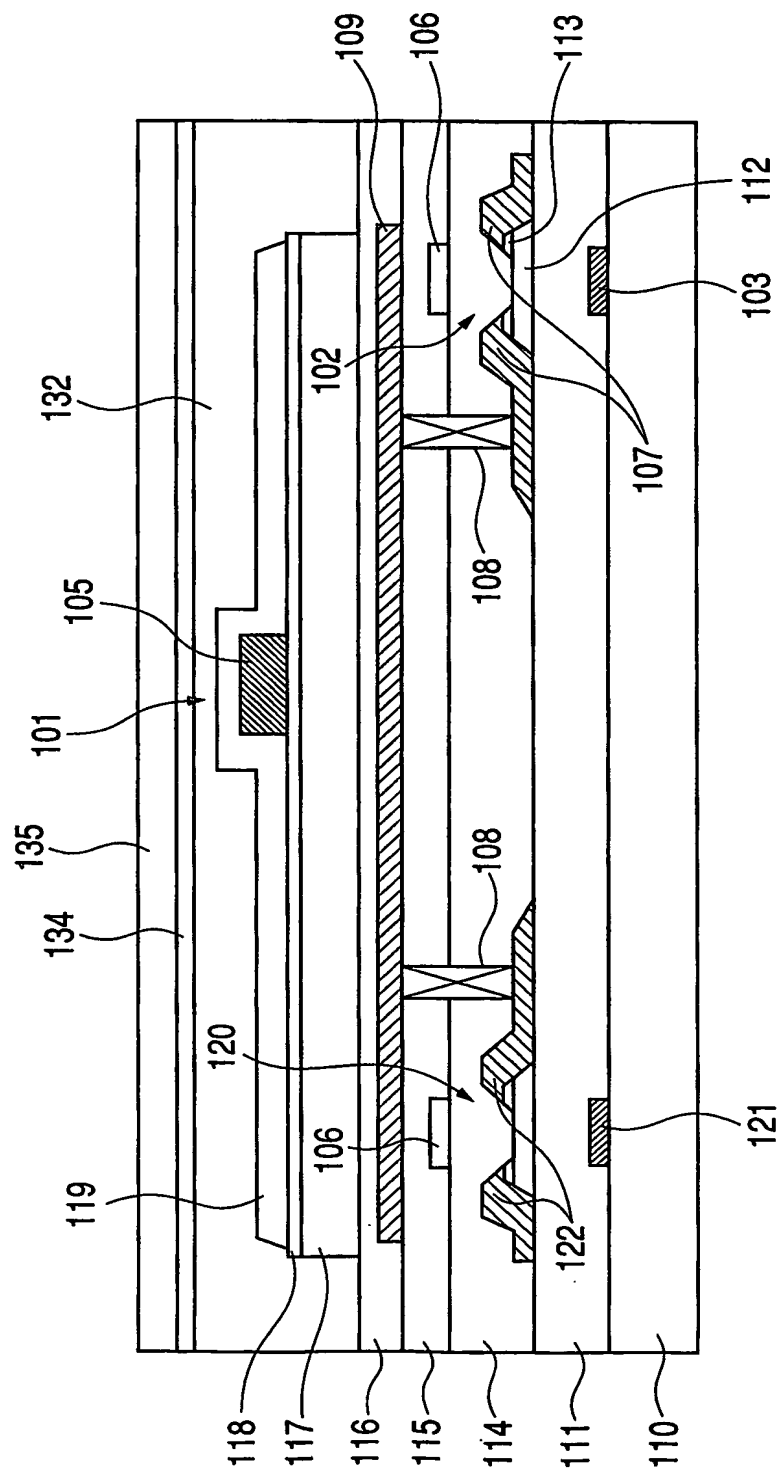
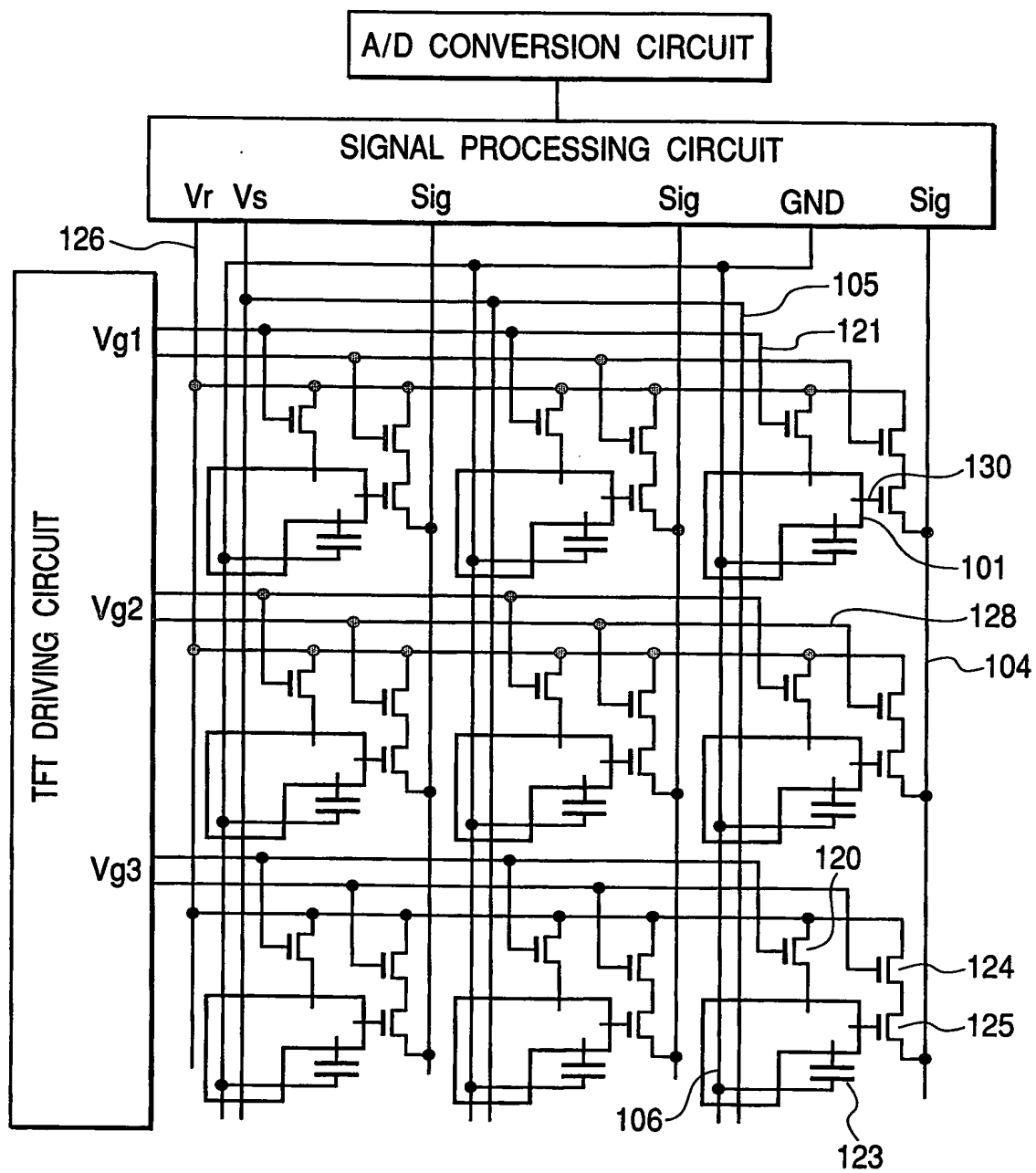
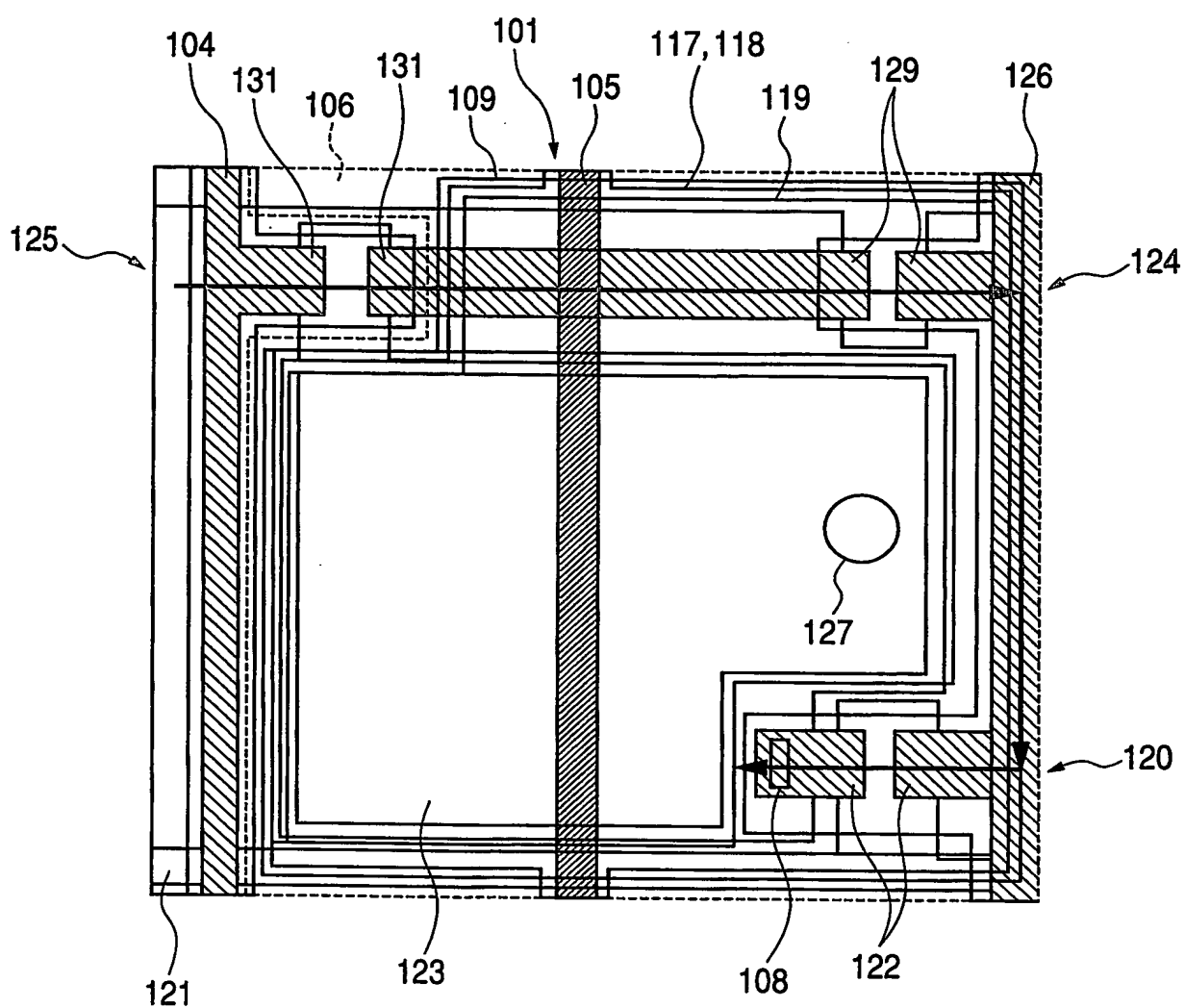


FIG. 8



**FIG. 9**



**FIG. 10**

11 / 13

*FIG. 11*

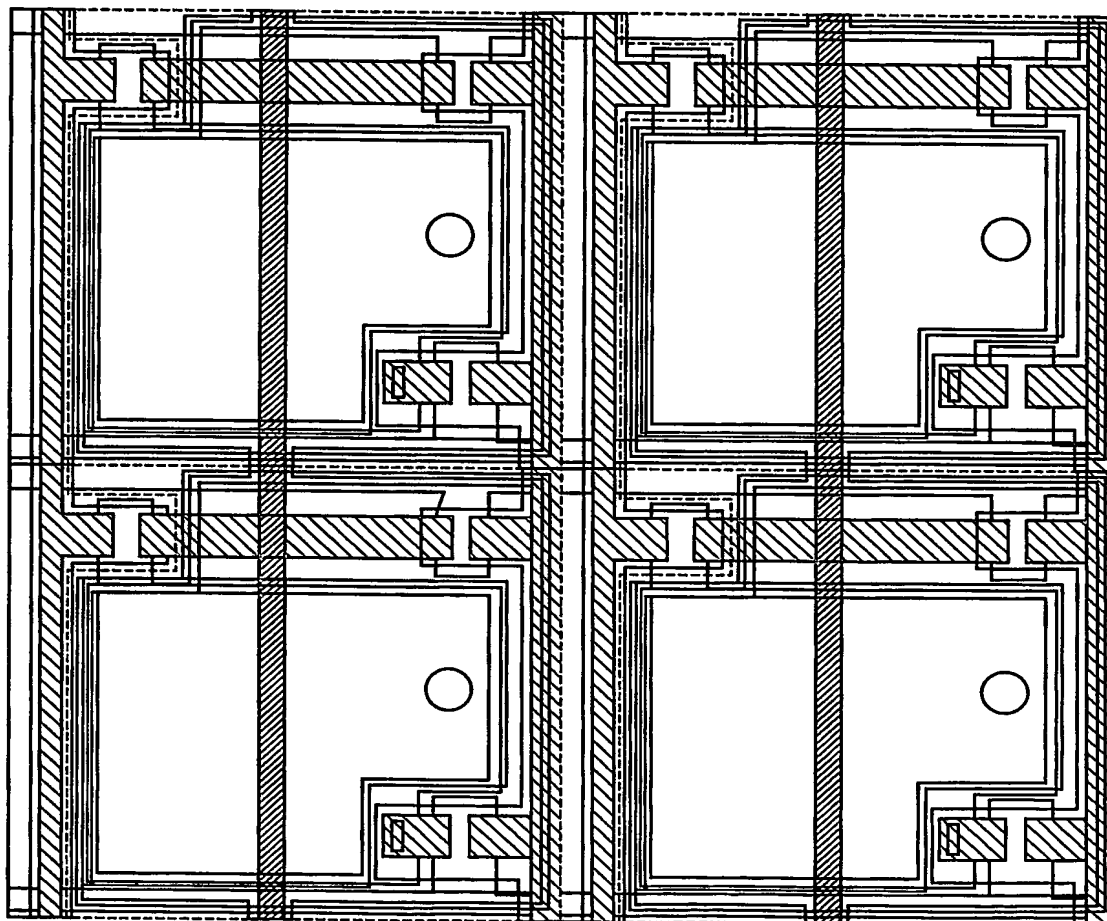
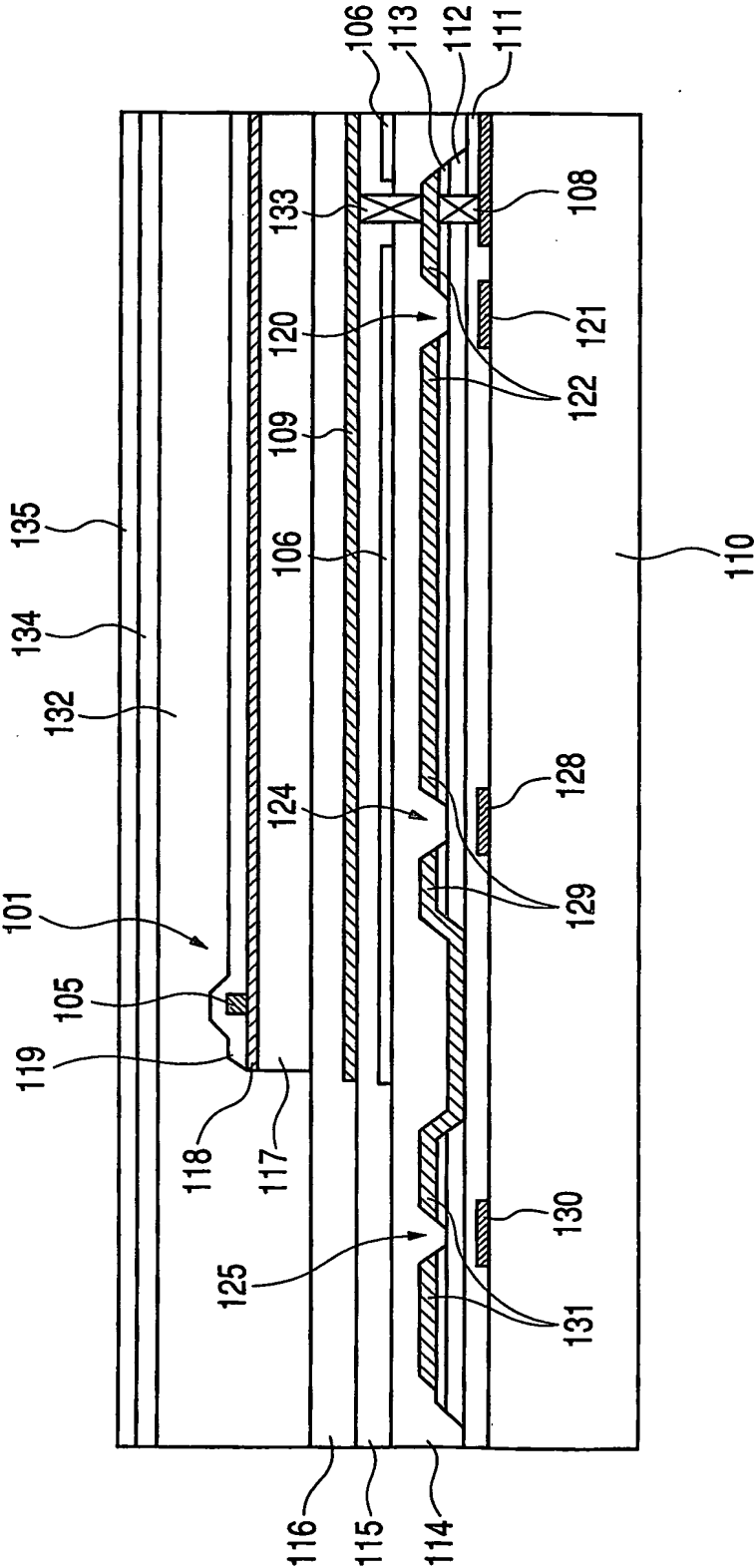
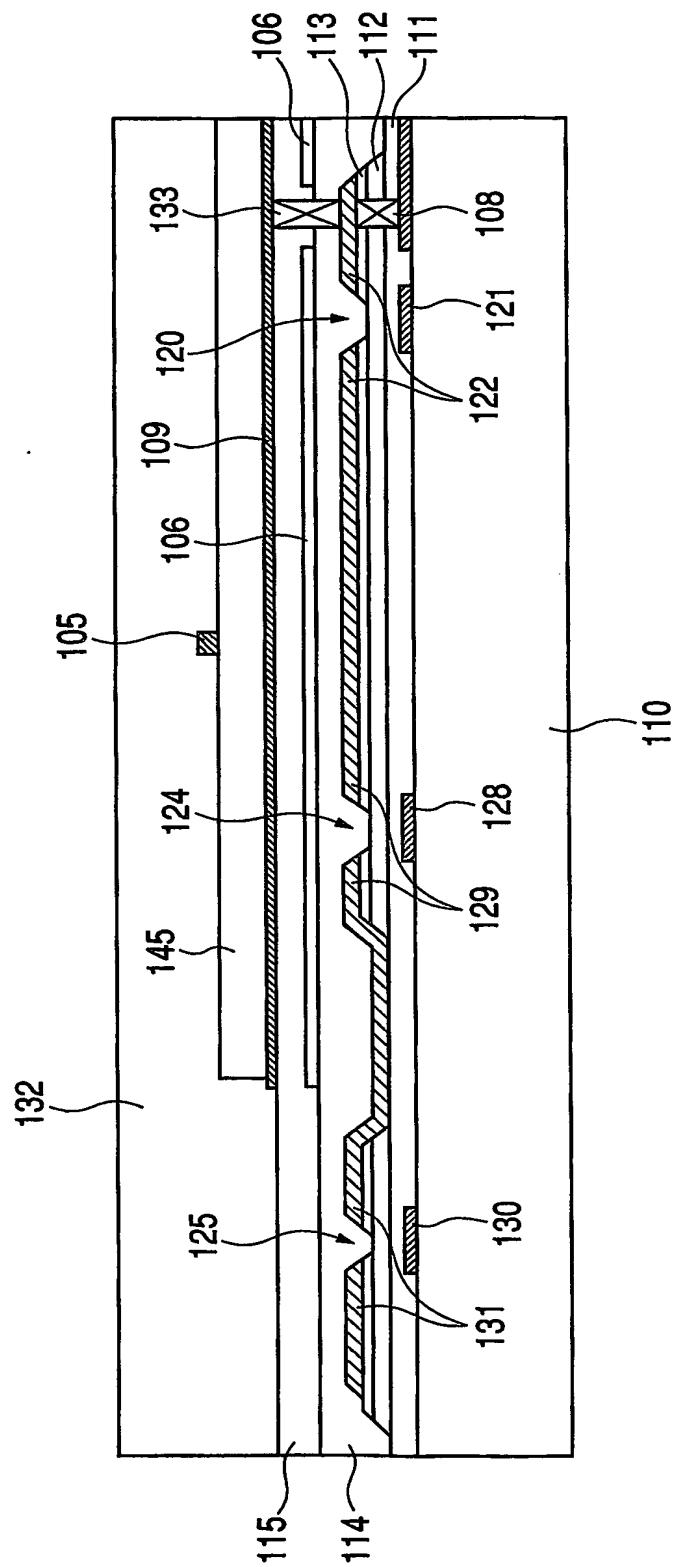




FIG. 12



13 G. L.



## A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl.<sup>7</sup> H01L27/14, H01L27/146, H04N5/32

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl.<sup>7</sup> H01L27/14, H01L27/146, H04N5/32, H01L21/3205, H01L21/768

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
 Japanese Utility Model Gazette 1922-1996, Japanese Publication of Unexamined Utility Model Applications 1971-2004, Japanese Registered Utility Model Gazette 1994-2004, Japanese Gazette Containing the Utility Model 1996-2004

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-97660 A (SEMICONDUCTOR ENERGY LABORATORY CO., LTD.) 1999.04.09,	1, 2, 4, 6, 7, 10, 11
Y	whole document (Family none)	3, 15-17
A		5, 9, 12-14, 18
X	JP 11-121731 A (SEMICONDUCTOR ENERGY LABORATORY CO., LTD.) 1999.04.30,	1, 2, 4, 6, 8, 10, 11
Y	whole document (Family none)	3, 15-17
A		5, 9, 12-14, 18
Y	JP 2000-156522 A (CANON KABUSHIKI KAISHA) 2000.06.06, whole document (Family none)	3, 15-17
A		5, 9, 12-14, 18
Y	US 6323490 B1 (KABUSHIKI KAISHA TOSHIBA) 2001.11.27, whole document & JP 11-274524 A	10, 11



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

07.05.2004

Date of mailing of the international search report

25.5.2004

Name and mailing address of the ISA/JP

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan

Authorized officer

MASAAKI AWANO

4M

9353

Telephone No. +81-3-3581-1101 Ext. 3462

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2004/001429

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5136358 A (FUJI XEROX CO., LTD.) 1992.08.04, whole document & JP 4-42934 A	10, 11
Y	JP 2-82555 A (HITACHI LTD.) 1990.03.23, whole document (Family none)	10, 11
Y	JP 62-86857 A (FUJI PHOTO FILM CO., LTD.) 1987.04.21, whole document (Family none)	15, 16
Y	JP 2000-241557 A (KABUSHIKI KAISHA TOSHIBA) 2000.09.08, whole document (Family none)	17